(12) UK Patent Application (19) GB (11) 2 111 273 A

(21) Application No 8231379
(22) Date of filing 3 Nov 1982
(30) Priority data
(31) 8133160
(32) 3 Nov 1981
(33) United Kingdom (GB)
(43) Application published 29 Jun 1983
(51) INT CL³ G08B 25/00
(52) Domestic classification G4H 13D 13F 14A 14B 14D 60 ND U1S 2188 2195 G4H
(56) Documents cited
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GB 0918790
GB 0811169
GB 0589369
GB 0460904
GB 0266798
GBA 2090682
GBA 2082358
(58) Field of search G4H
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(54) Multiple detector circuit

(57) A detector circuit for operating an alarm from a number of separate detector elements, includes a control unit capable of sensing which detector element has been actuated or short circuited. The individual detector elements are conveniently switches (12) each located in parallel with a resistor (11) which is itself in series with a further resistor (13), and the parallel resistors (11) are all different values. Thus by sensing the overall impedance of the circuit the control unit can detect any individual detector. The switches are preferably arranged in a single series loop, though they may be in parallel. A reactuation circuit includes an automatic datum reset to adjust to a new value after a detector has been actuated.

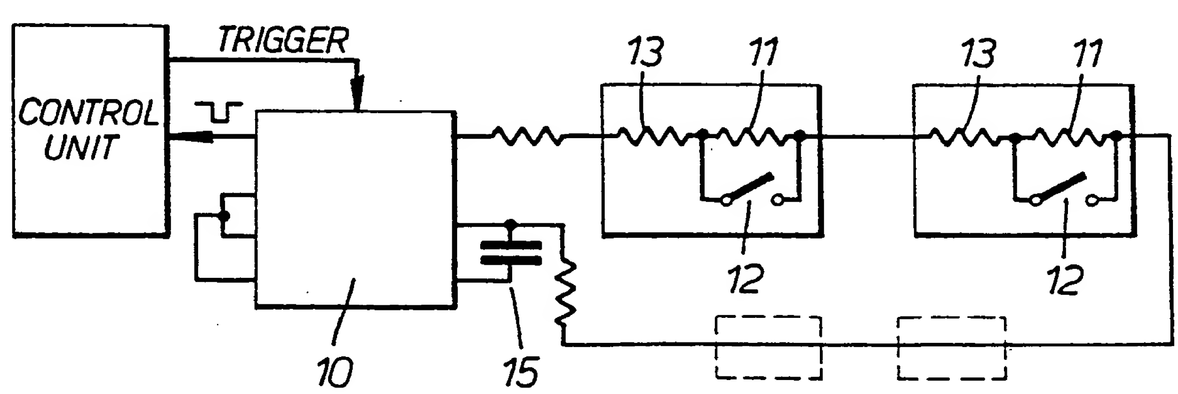

FIG. 1.

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

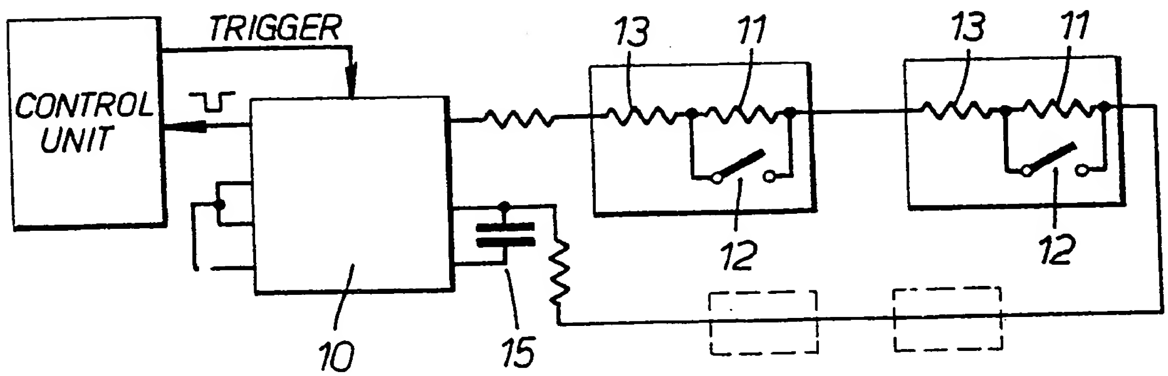


FIG. 1.

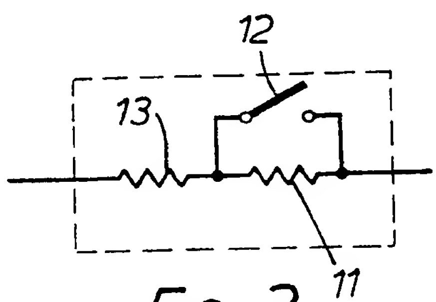


FIG. 2.

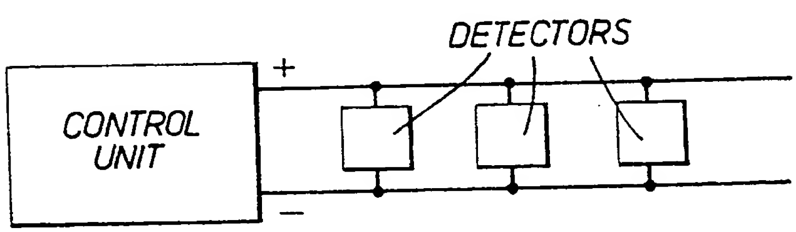
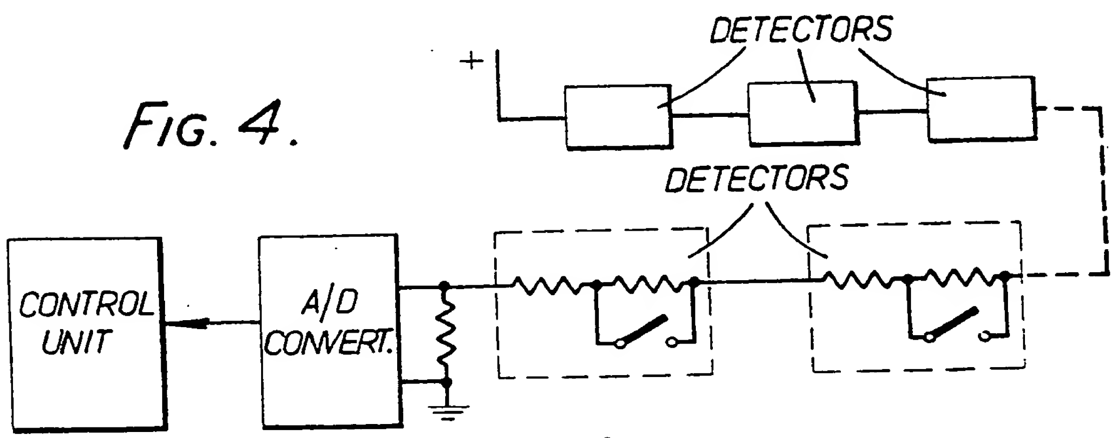


FIG. 3.

FIG. 4.



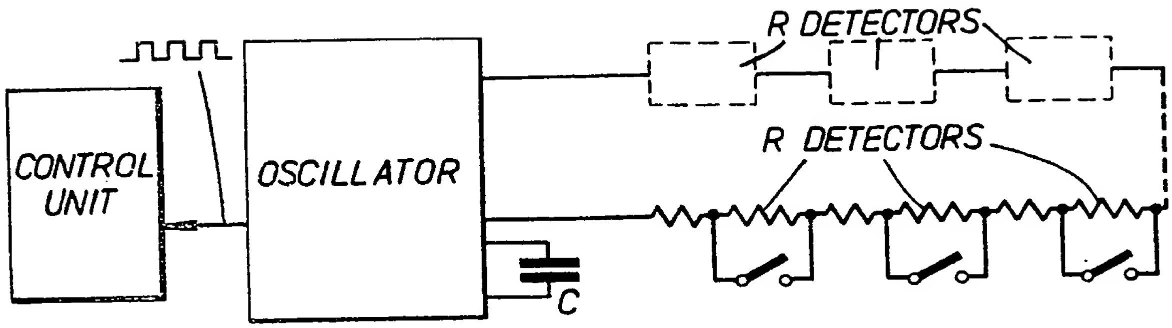


FIG. 5.

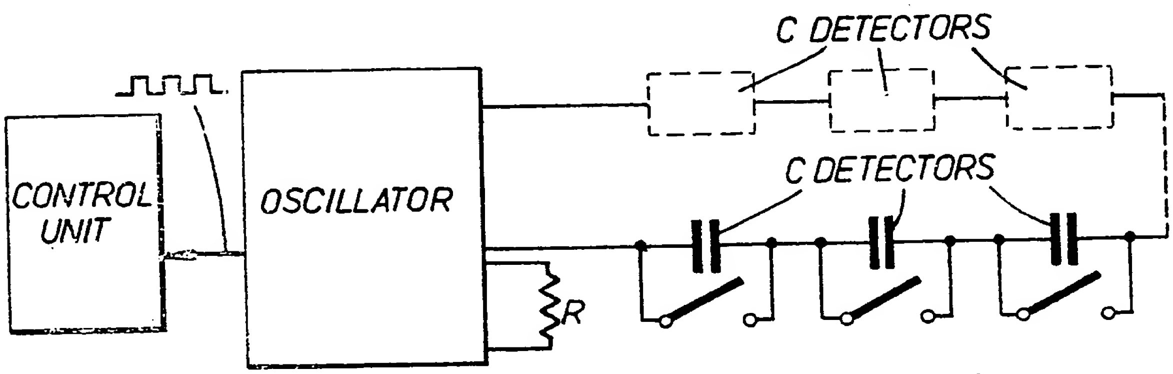


FIG. 6.

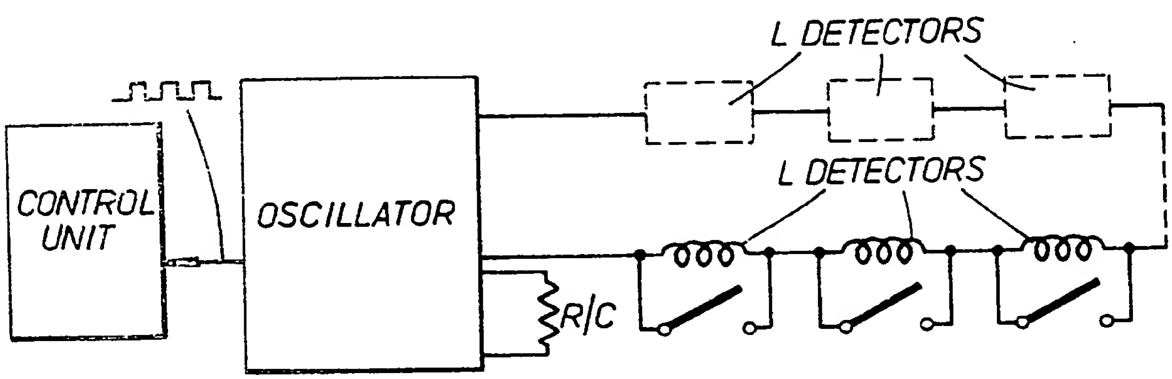


FIG. 7.

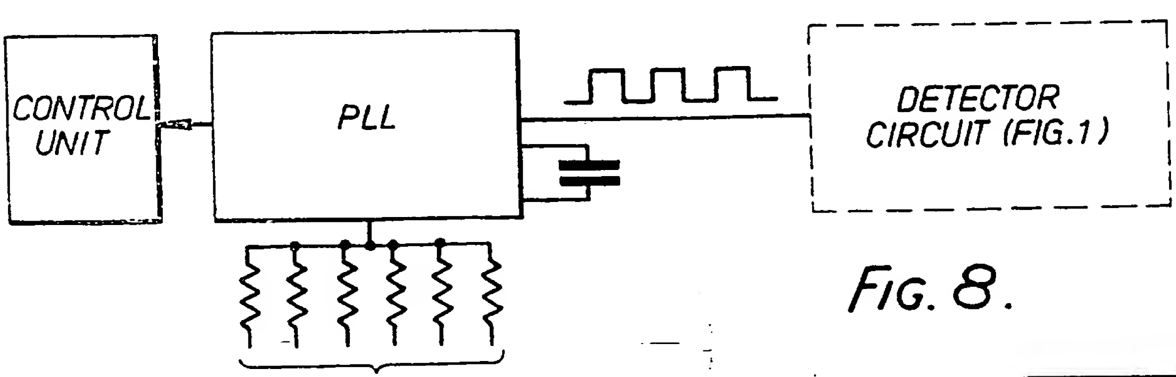


FIG. 8.

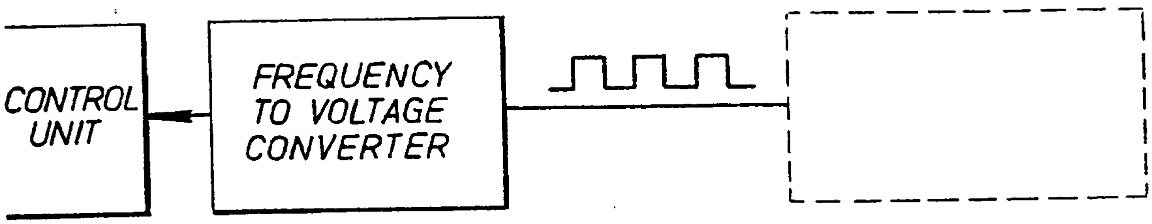


FIG. 9.

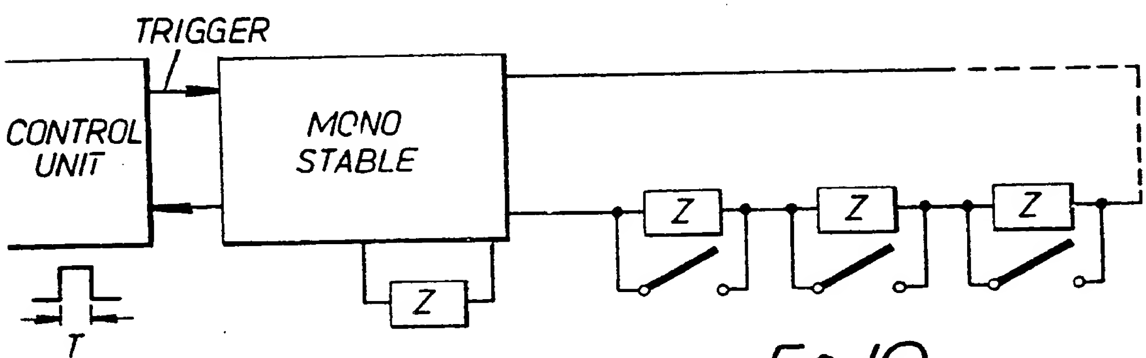


FIG. 10.

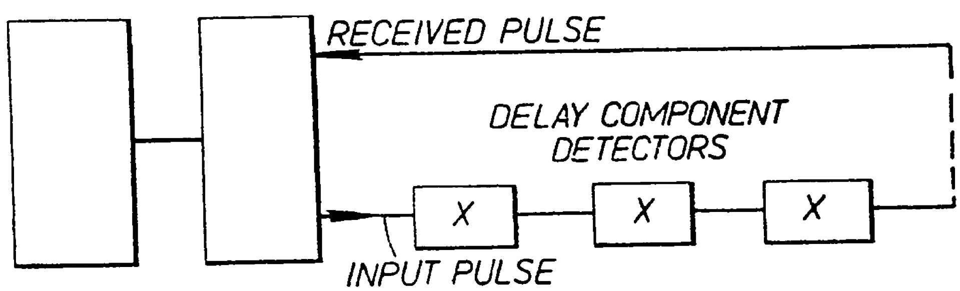


FIG. 11.

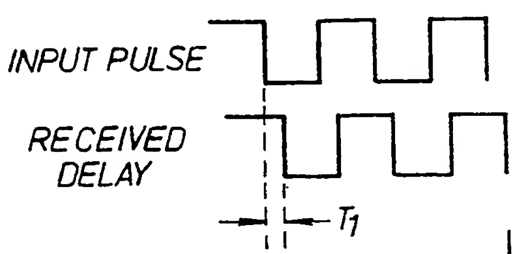
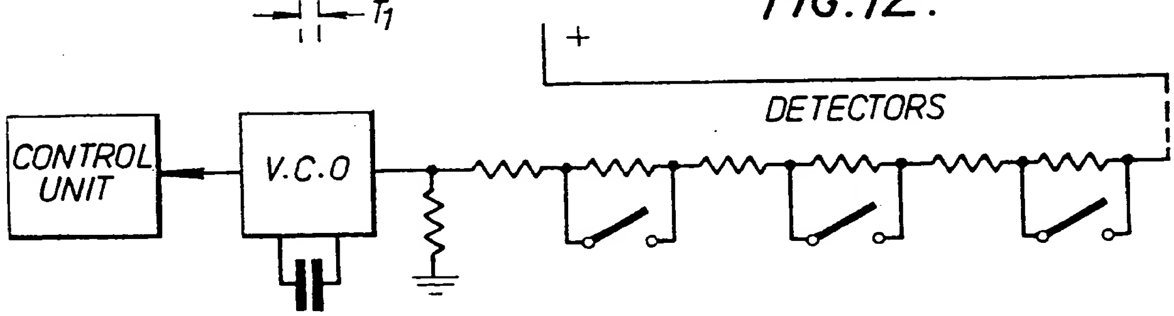


FIG. 12.



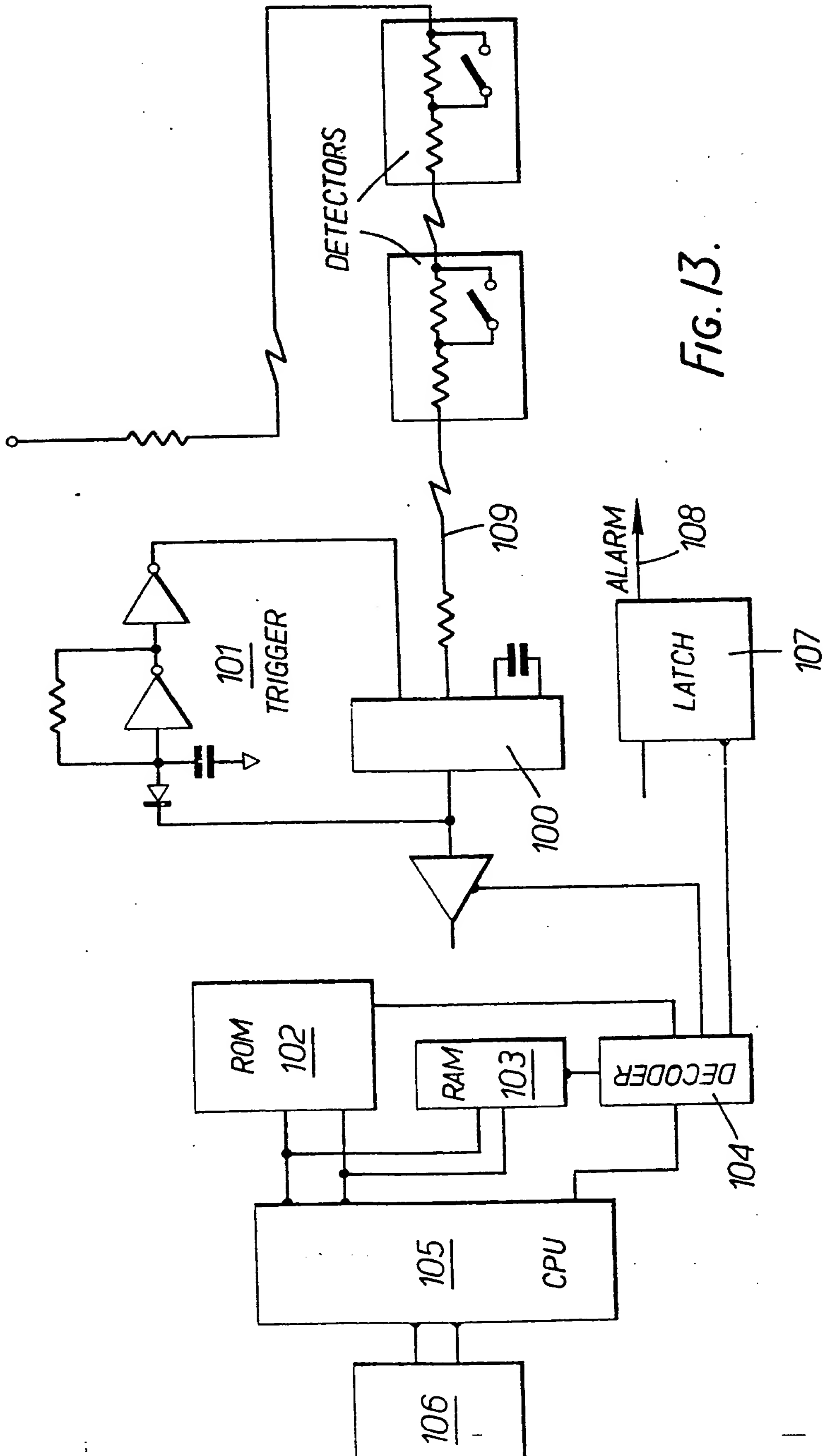

DETECTORS
109
ALARM
108
101
TRIGGER
LATCH
107
100
ROM
102
RAM
103
DECODER
104
105
CPU
106

FIG. 13.

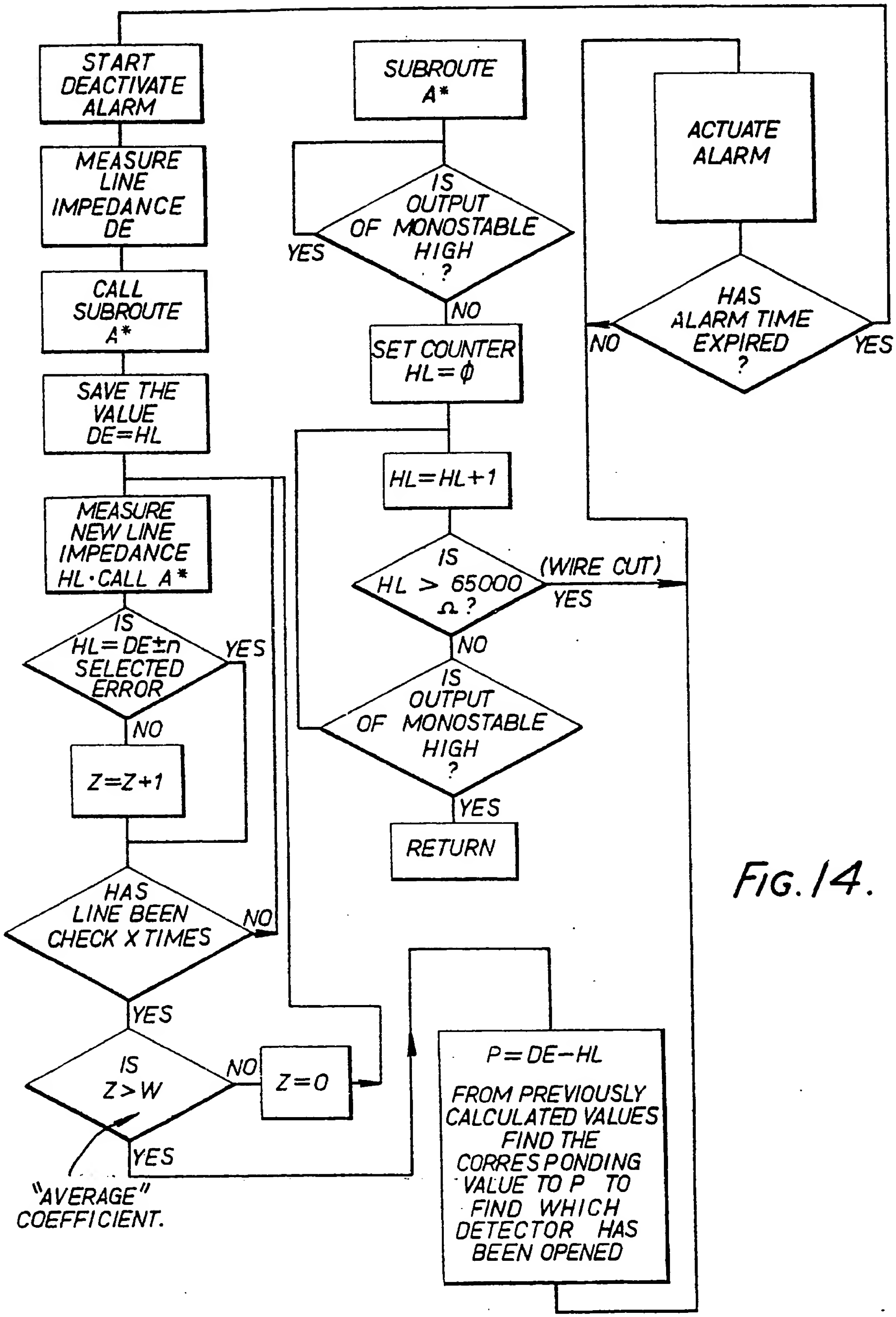

START DEACTIVATE ALARM
MEASURE LINE IMPEDANCE DE
CALL SUBROUTE A*
SAVE THE VALUE DE=HL
MEASURE NEW LINE IMPEDANCE HL·CALL A*
IS HL=DE±n SELECTED ERROR
YES
NO
Z=Z+1
HAS LINE BEEN CHECK X TIMES
NO
YES
IS Z>W
NO
Z=0
YES
"AVERAGE" COEFFICIENT.
SUBROUTE A*
IS OUTPUT OF MONOSTABLE HIGH ?
YES
NO
SET COUNTER HL=φ
HL=HL+1
IS HL > 65000 Ω ?
(WIRE CUT)
YES
NO
IS OUTPUT OF MONOSTABLE HIGH ?
YES
RETURN
P=DE−HL
FROM PREVIOUSLY CALCULATED VALUES FIND THE CORRESPONDING VALUE TO P TO FIND WHICH DETECTOR HAS BEEN OPENED
ACTUATE ALARM
HAS ALARM TIME EXPIRED ?
NO
YES

FIG. 14.

SPECIFICATION

Multiple detector circuits

This invention relates to an electrical circuit which includes a plurality of detector elements and a a control device sensitive to the operation of individual detector elements. Such systems are commonly used for example as intruder alarm circuits or in general as an indicating or warning system to give notice of the actuation or malfunction of a number of components or sensors.

A problem which arises in such systems is the need to identify individual detectors. For example, in the case of an intruder alarm circuit it may be desired that a number of indicators on particular selected doors and windows should be temporarily disconnected from the circuit, to allow for movement of the occupants in one part of the property while the remaining parts of the property are still protected by the circuit. The ability to identify and control the detector elements individually can be achieved by multiple connector lines each having two or more conductors running from the master control unit to the individual detectors. This, however, suffers from a number of disadvantages. The cable is relatively expensive, but more importantly it is laborious and expensive to install and may be unsightly. Also, the additional length of connector cable inherently increases the vulnerability of the system.

Another problem of existing detector systems is the liability to malfunction caused by innocuous but unavoidable external interference. For example, if a connecting cable passes close to a fluorescent tube it will inevitably pick up random frequencies emitted by the tube circuit and these frequencies cannot easily be filtered out, and result in a high level of "noise" which can cause malfunction in components of the circuit.

Accordingly it is an object of the invention to provide an improved alarm circuit which will at least partly satisfy some of the existing problems and disadvantages.

Broadly stated from one aspect the invention consists in a detector circuit comprising a control unit and a plurality of physically spaced detector elements, the detector elements being electrically interconnected with each other and with the control unit, and each element having an electric component whose characteristic value varies in accordance with the condition of the element, the control unit being arranged to sense the overall characteristic value of the circuit and hence to locate the individual varied elements.

According to a preferred feature of the invention the detecting elements are connected in series, or in parallel, and each includes a switch or other variable control device in parallel with an electrical component (R, L or C). In many cases it is also of advantage that each switch or control device should be in series with a further component of the same or different type (R, L or C).

A particularly convenient system for locating individual elements is to arrange for the characteristic values of individual components to be different. In most cases it is important that all the values of the components should differ from each other and according to another preferred feature of the invention the components have values proportional or directly related to prime numbers.

In one particular form of the invention the electrical elements are connected to form part of a voltage divider circuit and the control unit is arranged to be responsive to changes in the voltage at one terminal of the circuit.

In any case, it is usually desirable that the circuit should include means for applying a pulsing or oscillating current to the circuit and means for sensing changes in the characteristics of the pulses or wave forms transmitted through the circuit.

In one type of circuit according to the invention the control unit includes an analogue sensor or comparator, and an analogue-to-digital convertor connected to a digital output.

Since individual components are not always of the specified value within a high order of accuracy (unless very expensive components are used) it is desirable that the circuit should produce reliable output signals even with variable values of the components, the noise level on the circuit, and the supply voltage. Thus in some forms of the invention the control unit includes an averaging circuit or a multiple sampling circuit arranged to produce a plurality of successive indications of a characteristic value of the circuit, and to provide an output dependent upon the number of sample readings in any selected group which meet a specified limiting value or values.

The control unit may include a mono-stable device having a trigger input from a timing circuit and the control circuit in some forms of the invention includes a voltage controlled oscillator whose frequency varies with the applied voltage.

The invention may be performed in a variety of different ways and details of some specific preferred forms and embodiments will now be given by way of example with reference to the accompanying drawings which are simplified circuit diagrams.

If the switches are connected in series (as is the case in most alarm systems) there will be a signal to the control box whenever any one switch is open, but this results in a non-flexible system. Preferably all the switches are in series in a single loop line and yet it is still possible to determine if one or more switches are open at any one time. A preferred example is shown in Figures 1 and 2. It comprises a mono-stable multivibrator or pulse generator 10 (in this case a 74121 because it will produce an accurate pulse). A resistor 11 is placed in parallel with every switch 12 and the loop 14 including all the switches in series is used as the timing resistor for the mono-stable. The value of the timing capacitor 15 is determined by the width of the pulse that is required by the control box (not shown).

Since the maximum timing resistor for a 74121 mono-stable is 25 K ohm, it is preferred to use standard 470 ohm ± 5% resistors. This allows a maximum of 53 switches (lower value resistors could be used but will make the control box more complicated in terms of accuracy). To comply with the British standard and make the loop tamper proof in the case of an alarm system each switch preferably includes the parallel resistor 11 and the series resistor 13 which prevents the circuit being negated by a short placed across the wires leading to the switch, see Figure 2. Each switch can be in a variety of forms but normally a reed switch is preferred for an intruder alarm circuit.

With the above values the circuit will produce a pulse of 1 mS pulse width for every switch that is open. Therefore with 25 switches for example a pulse width of 25 mS is produced, and a change of 0.5 mS in the pulse width is produced for every switch closure.

In this particular case an MPU board based on a Z 80 microprocessor was used. The state of the individual switches is determined by the control box triggering the mono-stable, whereupon the time between the falling and rising edge of the pulse is measured. Now if any switch is closed or opened this time value will change, and by subtracting the two values it can be determined if and in what way the state of the line has been changed. Since the time measured by the control box might just miss the rising edge or falling edge of the pulse it is preferred to use a counter (in the above case by incrementing one of the Z 80's double registers). The falling edge of the pulse will start this counter and the rising edge will stop it. The rate being 18 uS/count it will require a count of 27-28/470 ohm resistor to overcome the accuracy of the count caused for example by changes of the resistors' value or changes in voltage. If the two readings are within −10 to + of the count they are accepted. The draw back of this system is that the loop is prone to noise. To overcome this, the value of the count may be compared with the determined value, and if 3 out of 5 times it is found to have differed then it can be assumed safely that one or more switches have changed status.

If the control box needs to know exactly which switch is open or closed the value of the resistors that are used in the switches must differ. The preferred method of calculating the value of these resistors is to decide on a base value resistor R and choose the rest of the values as a prime number multiplied by the base value (e.g. 1 × R, 2 × R, 3 × R, 5 × R, 7 × R and so on) ensuring the total value of the resistors will not exceed the 25 K ohm limit of the 74121 mono-stable. If more switches are needed than this will allow, a CMOS or transistor mono-stable could be used. Instead of resistors capacitors can be used in the switches, and a fixed timing resistor can be used to replace the timing capacitor of the 74121.

The circuit as described above may be modified in a number of ways to achieve similar or different effects.

(a) If a voltage controlled oscillator is used instead of the mono-stable, and a square wave is produced having a frequency proportional to value of the resistors, then either the number of pulses can be counted for a fixed period of time or as is the case of the mono-stable the pulse width of any pulse can be measured. It can be seen that this method will overcome the problem of a noisy environment.

(b) If the loop is arranged as one part of a voltage divider resistor circuit then the voltage change at a reference point is proportional to the state of the switches. This voltage signal can either be used directly by an analogue control box or converted to digital form by the use of an A/D converter. The output of the A/D could either be fed directly to the control box or can be connected to a comparator. If the reference voltage of the comparator is controlled by the control box (e.g. resistor ladder or D to A) then the control box needs only concern itself when the output of the comparator is changed.

(c) The loop could be used as one of the timing components of an oscillator. These components could be a resistor, capacitor, or a coil and the frequency produced is varied and sensed in the same way as in (a) above.

(d) If the resistors are replaced by delay components, and a pulse is fed in at one end of the line, the time lag or difference between the input pulse and received pulse is measured and this time difference provides an indication of the state of the line of the individual detector elements.

(e) In the case of an "intelligence switch" (e.g. infra-red or some form of logic) one possible solution is to use a loop as in Figure 3, with the switches in parallel. The line supplies power to the individual devices and at the same time the information is modulated on the power line, and can be separated by use of selective filters. This results in some form of question and answer between the control box and each sensor detector element.

It can be seen that in most of the above cases the switches may be connected in parallel across the line instead of in series, but this will result in a change of the wave forms to logarithmic instead of the linear changes encountered with series connections.

The preferred forms of the invention use a single wire loop system for security alarms and are so arranged that the control box can recognise the individual sensors that are connected on the line (as many as they may be) and determine if each individual sensor is open or closed at any time. This can be achieved in a number of different ways:—

(a) Analogue to digital conversion (A/D). In this system, as shown in Figure 4, resistors are put in parallel with the switch contacts and a voltage is applied to the line such that closing and opening of contacts will change the voltage presented to the A/D, and so cause digital information to be presented to the control box.

(b) Oscillator. In this case, as in case (a) above, resistors are placed in parallel with the switch contacts, as shown in Figure 5, and a square wave is produced in which the width of the pulse is proportional to the total resistance of the line. Therefore if any switch contact is closed or open the frequency of the square wave will change and by arranging for the control box to measure the width of one wave (frequency of the signal) it can determine the state of the line. As can be seen from Figures 5, 6 and 7 there are three possible components R, C, L that can be used on the line to produce the desired effect. In the above cases the control box will measure the time (T) to determine the state of the line or it can use a phase lock loop (PLL) circuit to the same effect (Figure 8) or a frequency-to-voltage conversion in the case of an analogue control box (Figure 9).

(c) Mono-stables. In this case resistors or capacitors are used on the line to produce the timing chain for the mono-stable, and the mono-stable produces pulses having a width proportional to the state of the line. The time (T) is totally proportional to the number of Z's on the line, so by the control box measuring the time (T) it can determine which sensor is open or closed.

(d) Delay components. In this case a signal is sent by the control box and the time difference between sending the signal and receiving it back is measured. This time is directly proportional to the number of delay components on the line, and likewise by using components of selected different primary valves, individual components can be identified.

(e) Voltage controlled oscillator (VCO). In this case the impedance of the line is used to change the voltage presented to the VCO and a square wave is produced which has a width or frequency proportional to the line impedance. As in the case of (b) the square wave can be fed to a PLL or frequency-to-voltage converter circuit, or the control box can measure the time T.

(f) Measurement of line impedance. In this case a DVM can be used to measure the impedance of the line and present an analogue voltage to the control box.

In all the above cases a further resistor or other impedance is placed in series with the switch contacts to protect the contacts from being tampered with by placing a shorting wire across the contacts and so disabling the circuit. This feature produces a tamper-proof system and still retains the advantages of a one wire system.

An automatic reactivation system according to the invention is illustrated in Figures 13 and 14. The detectors are connected to a monostable vibrator 100 coupled to a trigger circuit 101 in the same way as in the example of Figure 1. The control unit includes an instruction ROM (Read Only Memory) 102 and RAM (Random Access Memory) or "scratch pad" 103, a decoder 104, which provides for control selection and sequencing, a central processor unit 105 and a clock and reset circuit 106. In addition, there is an output latch circuit 107 with an output 108 to an alarm.

The "flow diagram" of the circuit is illustrated in Figure 14. The CPU 105 reads the initial impedance value of the detector line 109 and repeatedly compares this with the new value of the line until it discerns a difference Z times out of W between the datum value and the new value. From its programme table it determines which sensor is open, and sounds the alarm. After a selected period the control deactivates the alarm, and revalues the line, i.e. inserts the new value as the datum value. Unlike a normal system where a line can have zero or a very high impedance, this method will always give an impedance value corresponding to the number of sensors open or closed on the line. Hence reactivation is achieved with protection for all the sensors. The series resistors connected to each detector switch also provide protection against short circuiting. If a short is placed across a detector the impedance of the whole line will change corresponding to the value of the series resistor. Thus the control unit detects if there has been an intrusion to the system, or a sensor opening. Moreover if the line is cut the overall value of the line impedance will be very high, and hence it can be detected.

Obviously this is only one way of measuring the impedance of the line and reactivating. It may be achieved with any of the other suggested circuits. For example, change of frequency can be used or change in voltage. If an "intelligent controller" is not used (e.g. CPU) the circuit can be arranged to compensate for the change in line impedance after the line activation and before the system has reactivated, e.g. by initiating a changing voltage until the output of the comparator reads zero (Figure 9) or by changing the input data to the PLL input (Figure 8).

In the accompanying drawings:—

Figure 1 is a simplified circuit diagram illustrating a series loop alarm circuit according to the invention,

Figure 2 illustrates one of the protection switch devices of Figure 1,

Figure 3 shows a twin cable parallel loop circuit according to the invention,

Figure 4 illustrates another possible modification,

Figures 5, 6 and 7 illustrate three possible circuits involving an oscillator input,

Figures 8 to 12 illustrate other forms of control circuitry,

Figure 13 illustrates a form of reactivation circuit according to the invention, and

Figure 14 is a programme flow diagram illustrating the functions of the circuit of Figure 13.

CLAIMS

1. A detector circuit comprising a control unit and a plurality of physically spaced detector elements, the detector elements being electrically interconnected with each other and with the control unit, and each element having an electric component whose characteristic value varies in accordance with the condition of the element, the

control unit being arranged to sense the overall characteristic value of the circuit and hence to locate an individual varied element.

2. A detector circuit according to Claim 1, in which the detecting elements are connected in series or in parallel, and each includes a switch or other variable control device in parallel with an electrical component (R, L or C).

3. A detector circuit according to Claim 2, in which each switch or control device is also in series with a further component of the same or different type (R, L or C).

4. A detector circuit according to Claim 1, or Claim 2, or Claim 3, in which the characteristic values of individual components are different.

5. A detector circuit according to Claim 4, in which all the values of the electrical components differ from each other.

6. A detector circuit according to Claim 4 or Claim 6, in which the electrical components have values proportional or directly related to prime numbers.

7. A detector circuit according to any of the preceding claims, in which the electrical elements are connected to form part of a voltage divider circuit and the control unit is arranged to be responsive to changes in the voltage at one terminal of the circuit.

8. A detector circuit according to any of the preceding claims, including means for applying a pulsing or oscillating current to the circuit and means for sensing changes in the characteristics of the pulses or wave forms transmitted through the circuit.

9. Apparatus according to any of the preceding claims, in which the control unit includes an analogue sensor or comparator, and an analogue-to-digital convertor connected to a digital output.

10. Apparatus according to any of the preceding claims, in which the control unit includes an averaging circuit or a multiple sampling circuit arranged to produce a plurality of successive indications of a characteristic value of the circuit, and to provide an output dependent upon the number of sample readings in any selected group which meet a specified limiting value or values.

11. Apparatus according to any of the preceding claims, in which the control unit includes a mono-stable device having a trigger input from a timing circuit.

12. Apparatus according to any of the preceding claims, in which the control circuit includes a voltage controlled oscillator.

13. A detector circuit including a control unit and a circuit comprising a plurality of detector elements electrically connected thereto, and each element having a characteristic electrical value which varies in accordance with the physical condition of the element, means for sensing the overall characteristic value of the circuit, and for producing an output signal when said overall value differs from a selected datum value, means for deactivating the circuit on receipt of said output signal, and then altering the datum value to correspond with the sensed overall value, and means for then reactivating the circuit.

14. A detector circuit according to Claim 13, in which the individual detector elements are each associated with a shunt component, and including means for comparing the overall characteristic value of the circuit including the shunt components with a selected datum value, and thereby detecting a short circuit applied across any one detector.

15. A detector circuit according to Claim 13 or Claim 14, including means for comparing the overall characteristic value of the circuit with an arbitrary limiting value, and thereby detecting a break in the circuit.

16. A detector circuit substantially in any of the forms described with reference to the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1983. Published by the Patent Office 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.